

AVOIDANCE OF BIRD REPELLENTS BY MICE (*Mus musculus*)

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Abstract—It is believed that mammalian chemosensory irritants are not aversive to birds and vice versa. Nevertheless, few avian repellents have been tested against mammals. For that reason, we evaluated the efficacy of 1.0% w/v methyl anthranilate, orthoaminoacetophenone, 2-amino-4',5'-methoxyacetophenone, 2-methoxyacetophenone, and veratryl amine as mouse repellents in 3-hr no-choice drinking tests. Relative to ingestion of plain water, all test substances significantly reduced ($P < 0.05$) intake. Orthoaminoacetophenone was the most effective repellent, with intake reduced to levels statistically indistinguishable from zero.

Key Words—Chemical repellents, chemosensory, mice, *Mus musculus*, orthoaminoacetophenone.

INTRODUCTION

Limited data are available that document agricultural losses caused by vertebrates (Salmon, 1988). Nonetheless, it is generally recognized that rats (e.g., *Rattus norvegicus*, *Rattus rattus*), mice (e.g., *Mus musculus*, *Peromyscus maniculatus*), voles (e.g., *Microtus pinetorum*, *Microtus pennsylvanicus*), various ground squirrels (e.g., *Spermophilus* spp.), and other rodents probably cause greater economic harm than any other vertebrate group (Brooks et al., 1990). Agricultural losses are believed to be substantial (Marsh, 1988), and damage is likely to increase in the future as conservation tillage practices become more

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widespread (Castrale, 1987). Besides crop damage, commensal rodents undermine and weaken structures (Marsh, 1988; Timm, 1982) and chew through electrical and telephone cables. They also may serve as primary reservoirs or hosts to vectors for human and livestock diseases, including viral zoonoses (e.g., Venezuelan equine encephalitis), rickettsial diseases (e.g., Rocky mountain spotted fever) and bacterial diseases (e.g., salmonella) (Gratz, 1988).

At present, there are a number of effective lethal strategies that can be employed for rodent control. There are few nonlethal options available, however, even though there are situations where nonlethal control is desirable. For example, rat and mouse infestations at swine confinement facilities often are maintained by the presence of palatable livestock feed. The development of a nontoxic rodent repellent that could safely be added to these feeds would have considerable utility, provided that it did not affect the palatability of the feed to swine. No available rodent repellent has this characteristic. Thus, although repellents like capsaicin or denatonium saccharide and denatonium benzoate are available, these materials are either broadly offensive to all mammals (Meehan, 1988) or show considerable inter- and intraspecific variability in effectiveness. Moreover, all of these materials are curiously inoffensive to birds (e.g., Beauchamp and Mason, 1991).

In the present experiment, we evaluated the repellency of five candidate bird repellents to house mice (*Mus musculus*). Although the available data suggested that at least some of these repellents were inoffensive to humans, livestock (e.g., Glahn et al., 1989; Mason et al., 1991c), and deer mice (*Peromyscus maniculatus*) (Schafer and Bowles, 1985), the overall evidence was sparse.

METHODS AND MATERIALS

Subjects. Seventy-two experimentally naive male CF-1 mice (*Mus musculus*) served as subjects. Animals were individually caged (27 × 21 × 14 cm) under a 12:12 light-dark cycle at 23°C and given free access to 8604-00 Wayne Rodent Blox.

Chemicals. We selected five stimuli previously shown to have avian repellent properties for this study: (1) methyl anthranilate (MA; CAS #134-20-3) (Kare, 1961; Kare and Pick, 1960), (2) orthoaminoacetophenone (OAP; CAS #551-93-9) (Mason et al., 1991b; Clark and Shah, 1991), (3) 2-amino-4',5'-methoxyacetophenone (AMAP; CAS #4101-30-8) (Clark et al., 1991), (4) 2-methoxyacetophenone (MAP; CAS #4079-52-1) (Clark et al., 1991), and (5) veratryl amine (VA; CAS #5763-61-1) (Mason et al., 1991a). All five chemicals were NPLC grade and were obtained from Aldrich Chemical Company (Milwaukee, Wisconsin). Each was added to deionized, distilled water to yield saturated emulsions with concentrations of 1.0% (w/v).

Procedure. Twelve mice (25–35 days old) were randomly assigned to each

of six treatment groups and adapted to an 18-hr water deprivation schedule. Adaptation was followed immediately by a four-day pretreatment period. On each pretreatment day, all animals were given 3-hr access to tapwater in 10-ml syringes fitted with sipper tubes. At the end of the 3-hr period, ingestion was measured, and the mice were permitted an additional 3-hr ad libitum access to water. Water tubes were then removed from cages, and animals were deprived until the following day.

A four-day treatment period immediately followed pretreatment. Treatment procedures were similar to those described for pretreatment, except that five groups were presented with their respective compounds in aqueous solution during the 3-hr measurement period. We continued to give the sixth group plain tapwater as a control.

Analysis. A three-way analysis of variance (ANOVA) with repeated measures over periods (two levels) and days (four levels) was used to assess the results (Winer, 1971). Chemical (six levels including the control group) was the independent factor in this analysis. In addition, for each chemical, a two-way repeated measures ANOVA was used to test for period and day effects. In all cases, Tukey tests (Winer, 1971, p. 201) were used to isolate differences among means ($P < 0.05$).

We also tested whether intake of treated water differed from a theoretical value of zero ingestion. This analysis required a slight modification in calculation of the treatment sums of squares, where the grand mean was replaced by zero and the degrees of freedom reflected the number of treatments considered in the experiment. Estimates of the error term remained the same as in a standard ANOVA.

RESULTS

Mice responded differently for each chemical across time (Figure 1) ($F = 4.5$, df 12, 165, $P < 0.001$). Relative to the pretreatment period, intake of all chemicals declined (AMAP: $F = 194.26$, df 1, 11, $P < 0.001$; MA: $F = 478.30$, df 1, 11, $P < 0.001$; OAP: $F = 736.55$, df 1, 11, $P < 0.001$; MAP: $F = 151.78$, df 1, 11, $P < 0.001$; VA: $F = 442.91$, df 1, 11, $P < 0.001$), with the exception of the control group, for which intake during the pretreatment and treatment periods was equal ($F = 1.79$, df 1, 7, $P = 0.223$). Intake of AMAP decreased across treatment days ($F = 2.88$, df 3, 33, $P = 0.051$), while mice increased their intake of MA, MAP, and VA ($F = 4.23$, df 3, 33, $P = 0.012$; $F = 12.94$, df 3, 33, $P < 0.001$; $F = 2.95$, df 3, 33, $P = 0.047$, respectively). Ingestion of OAP and water ($F = 0.72$, df 3, 33, $P = 0.549$; $F = 0.49$, df 3, 21, $P = 0.69$, respectively) remained constant across days.

OAP was the only chemical that reduced intake to a level not significantly different from zero ($F = 4.34$, df 1, 11, $P = 0.061$).

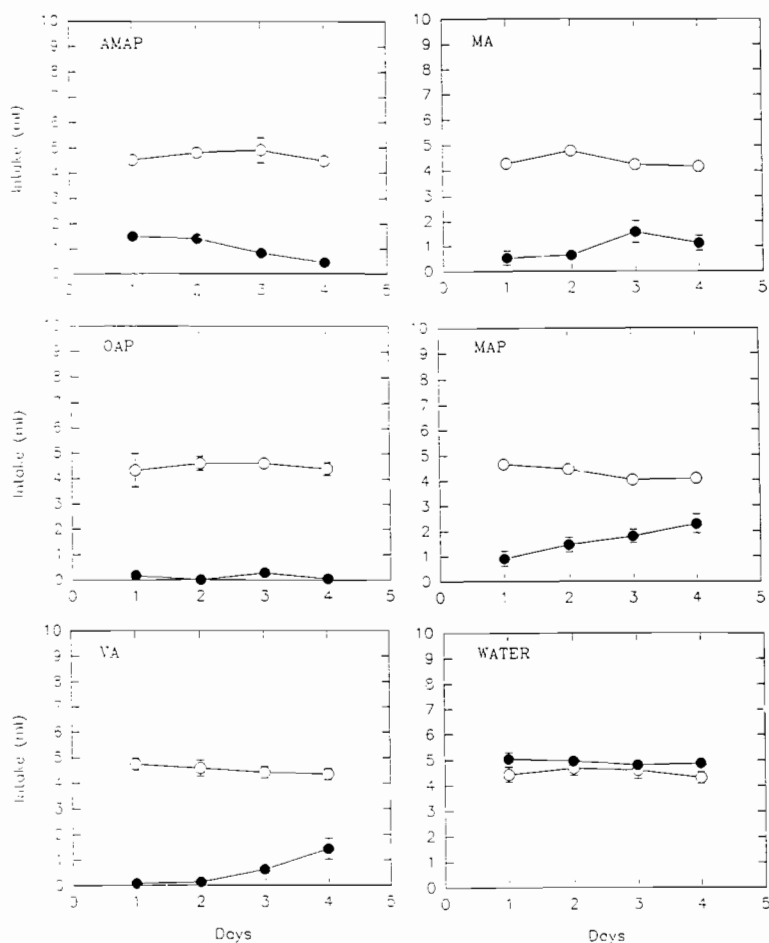


FIG. 1. Intake by mice of water during a four-day pretreatment period (open circles) and subsequent intake of 2-amino-4',5'-methoxyacetophenone (AMAP), methyl anthranilate (MA), orthoaminoacetophenone (OAP), 2-methoxyacetophenone (MAP), veratryl amine (VA), and water (control) during a four-day treatment period (solid circles).

DISCUSSION

All five chemicals substantially reduced intake relative to pretreatment levels, although MA, MAP, and VA showed signs of habituation (i.e., animals ingested more of these substances on the last day than the first day of treatment). Intake of these chemicals on the last day of the treatment period, however, was still substantially below levels of water drunk during the pretreatment period.

The most repellent material in the present experiment was OAP. This material effectively eliminated ingestion. The fact that the material appears substantially more repellent than MA is consistent with evidence showing that OAP is superior to MA as a bird repellent (Mason et al., 1991b).

Decreased ingestion of AMAP over time suggests that avoidance of this chemical involved learning. In other words, its effectiveness may depend partly on sensory factors and partly on food avoidance conditioning based on post-ingestional malaise.

Overall, the present results were surprising. At least one of the repellents (i.e., MA) is palatable to humans and livestock (Furia and Bellanca, 1975, p. 346; Glahn et al., 1989), and a prior report indicated that it is accepted by deer mice (Schafer and Bowles, 1985). Clearly, the notion that bird repellents are generally palatable to mammals is too broad. At least some bird repellents are offensive to at least some mammals.

Management Implications. While we are cautious about extrapolating from the laboratory to the field, the present results have clear practical implications. For example, one or another of the substances tested in the present experiment might be used as an additive to granular agricultural chemicals to reduce the hazards that these substances present to birds and rodents. In addition, they might be used as rodent and bird repellent seed treatments or livestock feed additives. Both laboratory (Mason et al., 1989) and field (Glahn et al., 1989) data suggest that anthranilate derivatives are effective bird repellent feed additives. The possibility that these materials also repel rodents would make them even more beneficial. Finally, we speculate that the repellents tested here might be incorporated into packaging, fabrics, and plastics to prevent damage by gnawing to electrical cables, containers, and other products where repellency must be instantaneous (i.e., no amount of damage is acceptable). All of the repellents tested in the present experiment appeared to have such immediate effects (i.e., they were offensive at first contact). Pilot tests in our laboratory suggest that OAP, MA, and VA do prevent gnawing of electrical cable, at least in short-term tests.

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